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(54) **SYSTEM AND METHOD FOR TRANSDUCER BIASING AND SHOCK PROTECTION**

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H04R 1/08	(2006.01)
H04R 17/02	(2006.01)

(52) **U.S. Cl.**

CPC .. ***H04R 3/00*** (2013.01); ***H04R 1/08*** (2013.01); ***H04R 3/007*** (2013.01); ***H04R 17/02*** (2013.01); *H04R 2201/003* (2013.01); *H04R 2410/00* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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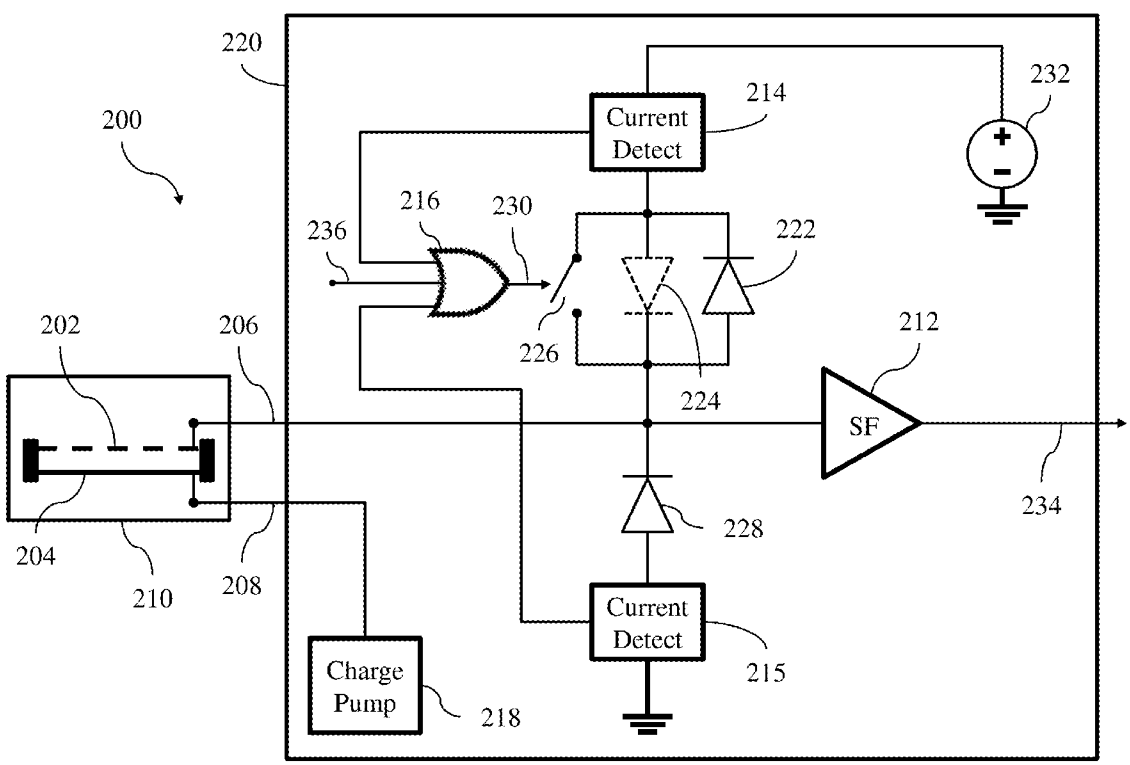
(57) **ABSTRACT**

In accordance with an embodiment, an interface circuit includes an amplifier configured to be coupled to a transducer, a first bypass circuit coupled to a first voltage reference and the amplifier, a second bypass circuit coupled to the first voltage reference and the amplifier, and a control circuit coupled to the second bypass circuit. The first bypass circuit conducts a current when an input signal amplitude greater than a first threshold is applied to the transducer and the control circuit causes the second bypass circuit to conduct a current for a first time period after the first bypass circuit conducts a current.

22 Claims, 7 Drawing Sheets



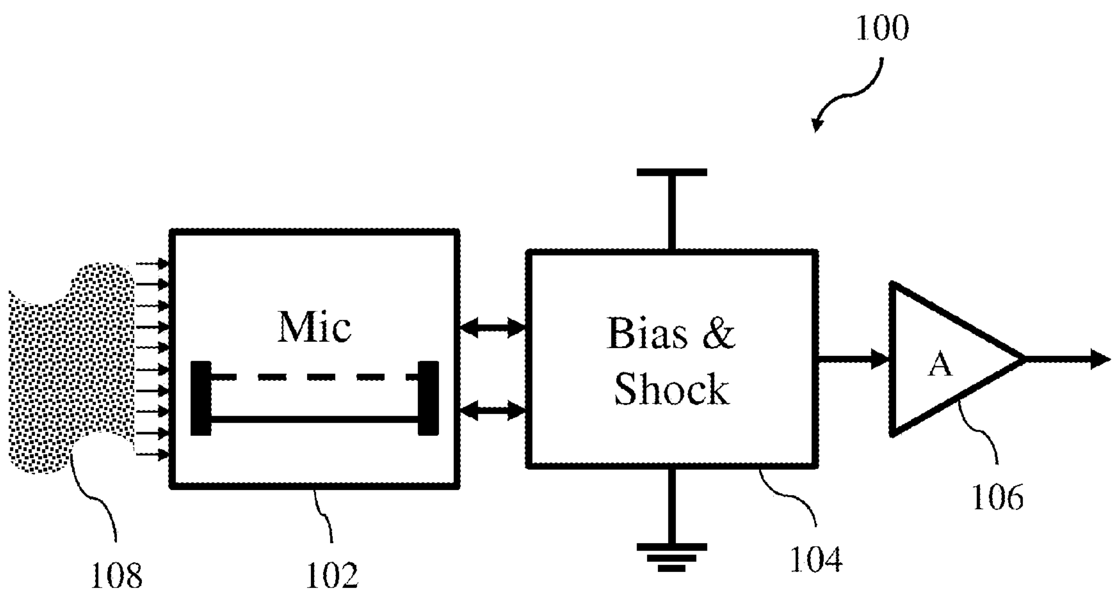


Figure 1

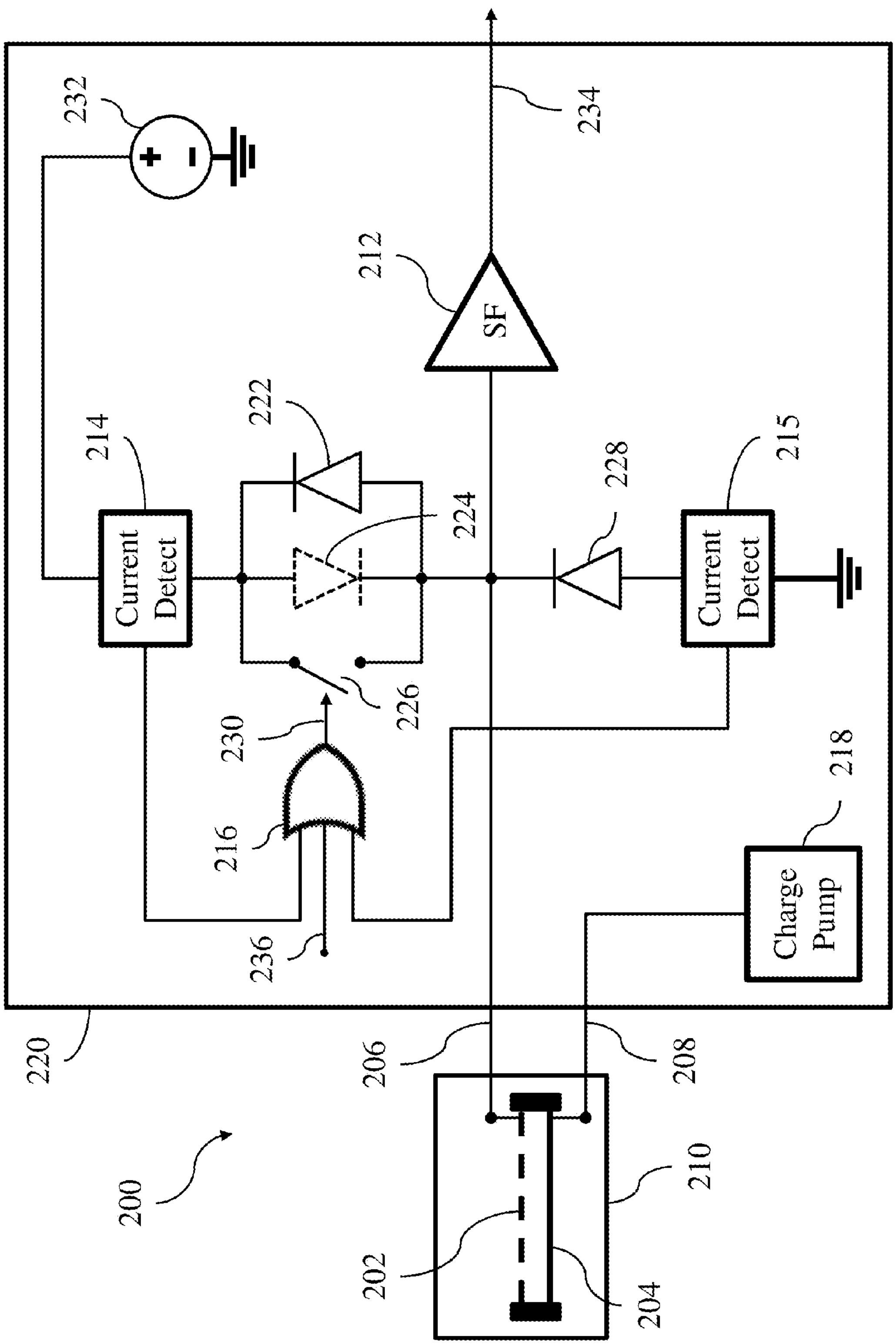
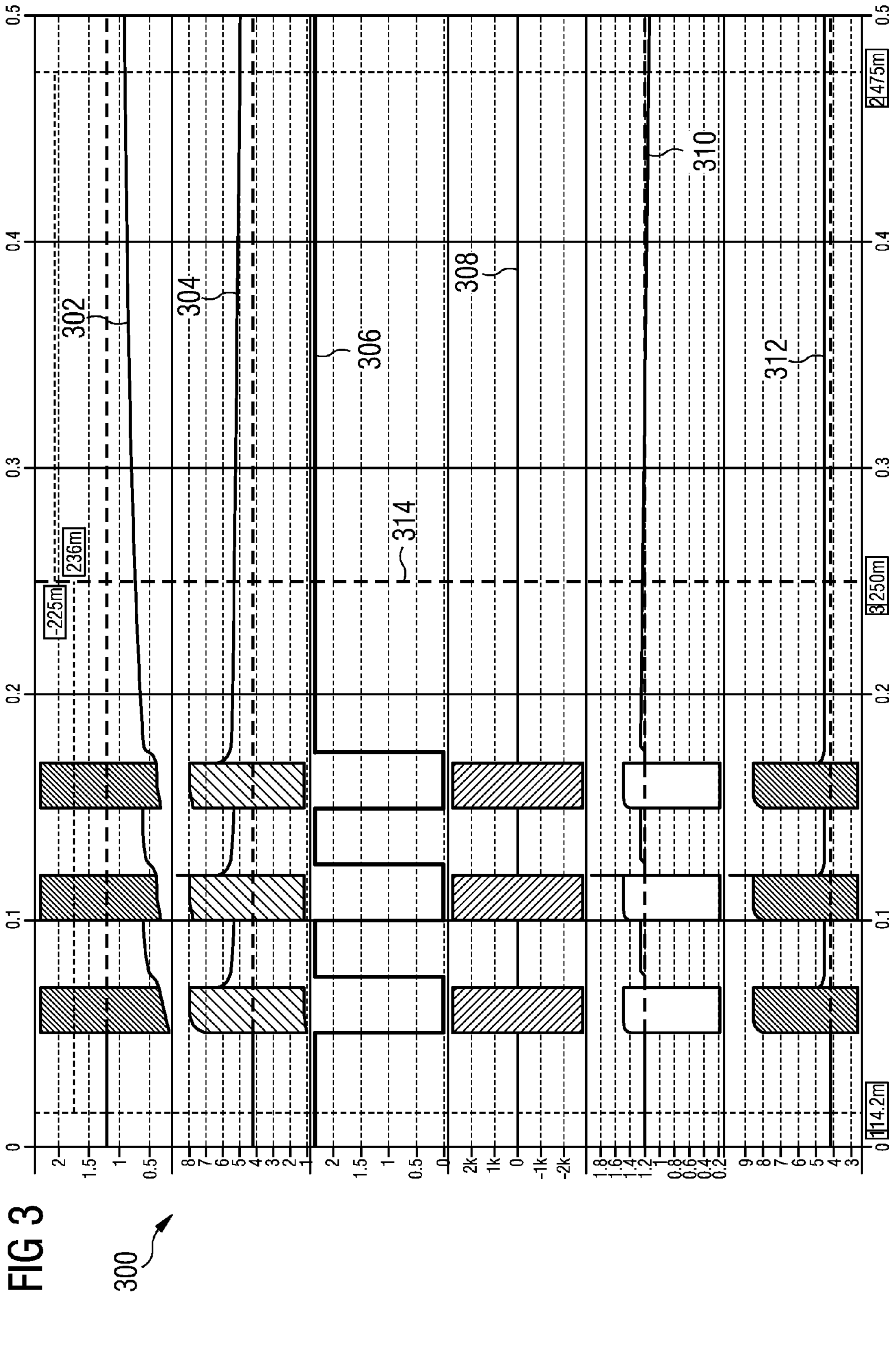

200
202
204
206
208
210
212
SF
214
Current Detect
215
Current Detect
216
218
Charge Pump
220
222
224
226
228
230
232
234
236

Figure 2

FIG 3


300
302
304
306
308
310
312
314
-225m
236m
250m
475m
114.2m
0
0.1
0.2
0.3
0.4
0.5

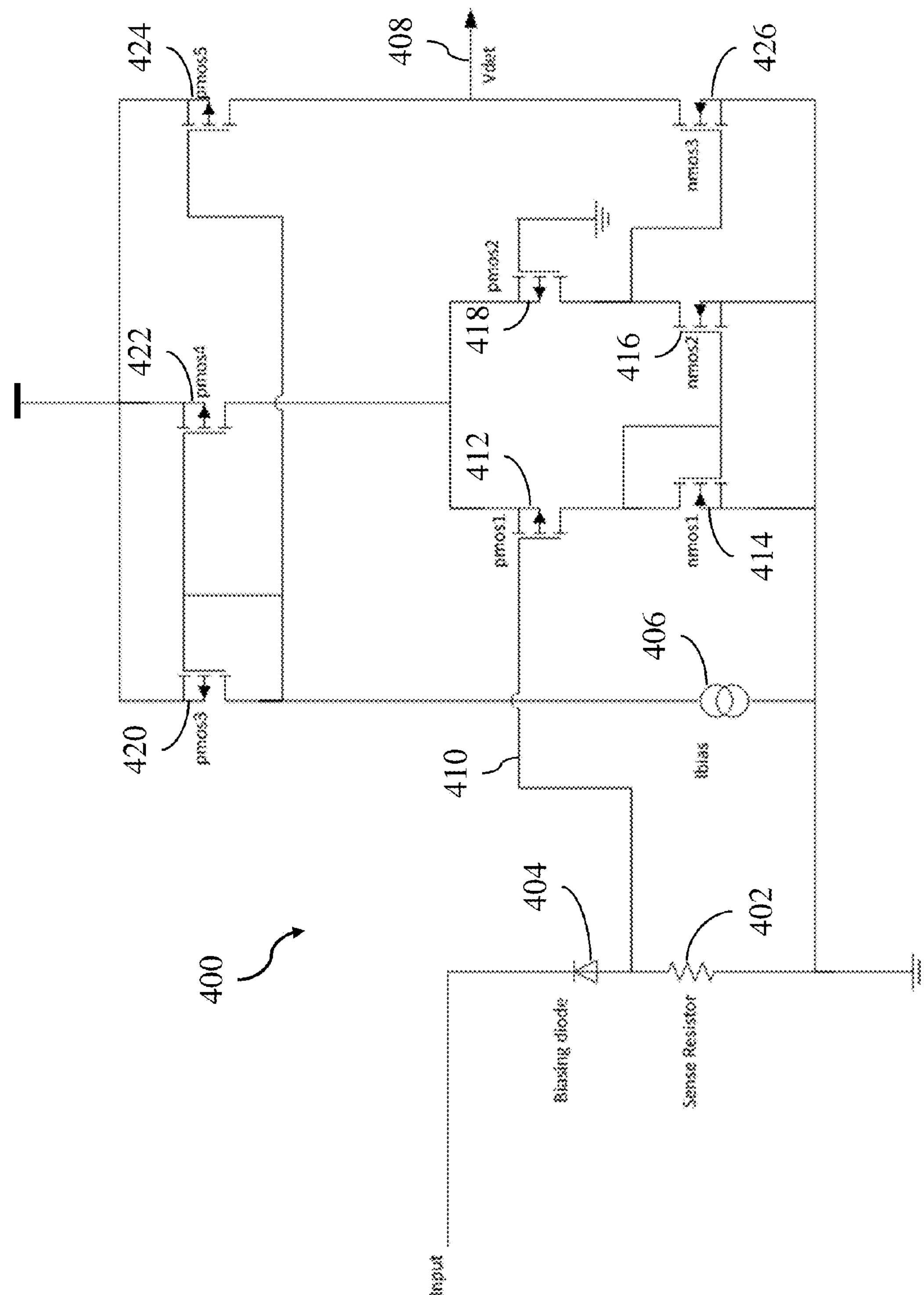

400
402
404
406
408
410
412
414
416
418
420
422
424
426
pmos1
pmos2
pmos3
pmos4
pmos5
nmos1
nmos2
nmos3
Vdet
Ibias
Biasing diode
Sense Resistor
Input

Figure 4

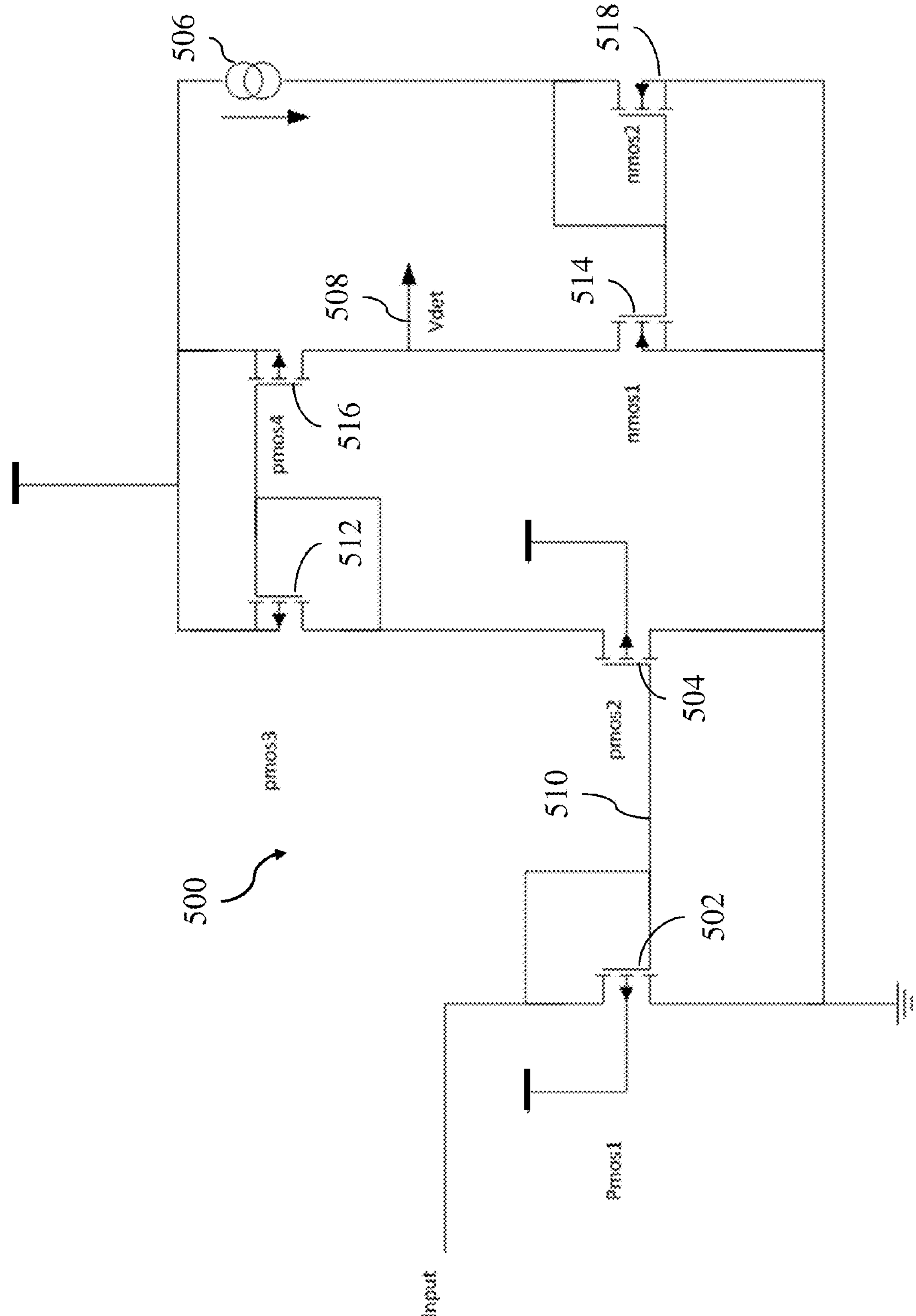
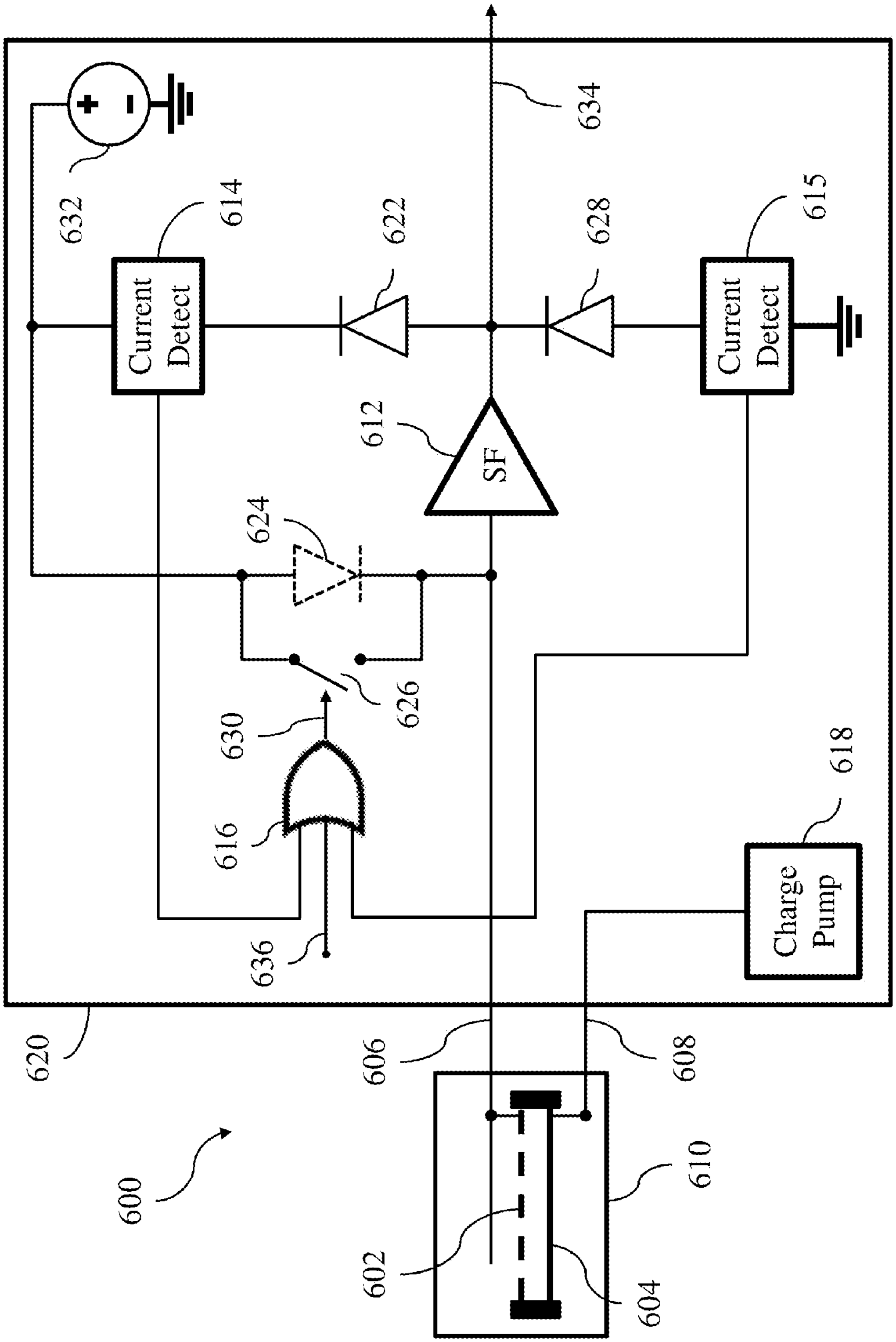

506
518
nmos2
508
Vdet
514
516
pmos4
nmos1
512
504
pmos2
510
500
pmos3
502
Pmos1
Input

Figure 5



Current Detect
Current Detect
SF
Charge Pump
600
602
604
606
608
610
612
614
615
616
618
620
622
624
626
628
630
632
634
636

Figure 6

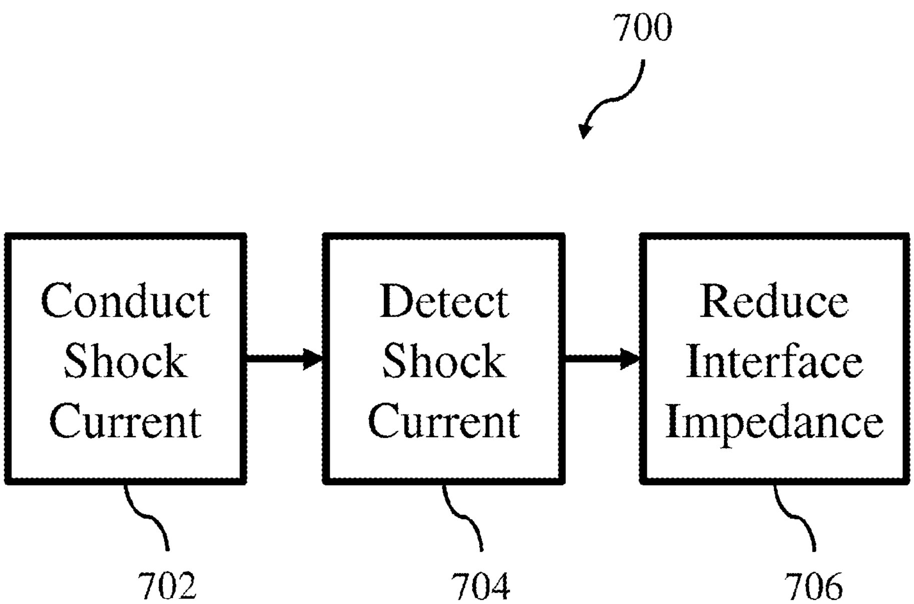

700
Conduct Shock Current
Detect Shock Current
Reduce Interface Impedance
702
704
706

Figure 7

SYSTEM AND METHOD FOR TRANSDUCER BIASING AND SHOCK PROTECTION

TECHNICAL FIELD

The present invention relates generally to transducers, and, in particular embodiments, to a system and method for transducer biasing and shock protection.

BACKGROUND

Transducers convert signals from one domain to another and are often used in sensors. A common sensor with a transducer that is seen in everyday life is a microphone, a sensor for audio signals with a transducer that converts sound waves to electrical signals.

Microelectromechanical system (MEMS) based sensors include a family of transducers produced using micromachining techniques. MEMS, such as a MEMS microphone, gather information from the environment through measuring physical phenomena, and electronics attached to the MEMS then process the signal information derived from the sensors. MEMS devices may be manufactured using micromachining fabrication techniques similar to those used for integrated circuits.

Audio microphones are commonly used in a variety of consumer applications such as cellular telephones, digital audio recorders, personal computers and teleconferencing systems. In a MEMS microphone, a pressure sensitive diaphragm is disposed directly onto an integrated circuit. As such, the microphone is contained on a single integrated circuit rather than being fabricated from individual discrete parts.

MEMS devices may be formed as oscillators, resonators, accelerometers, gyroscopes, pressure sensors, microphones, micro-mirrors, and other devices, and often use capacitive sensing techniques for measuring the physical phenomenon being measured. In such applications, the capacitance change of the capacitive sensor is converted into a usable voltage using interface circuits. In many applications, large amplitude physical signals caused by shock or similar events can overload the MEMS device and permanently or temporarily affect performance. In a MEMS microphone, shock events may affect an amount of charge on the capacitive plates. The performance of the MEMS, and especially the sensitivity, is related to the amount of charge on the capacitive plates. Thus, interface circuits for MEMS microphones are generally designed with charge biasing in mind.

SUMMARY OF THE INVENTION

In accordance with an embodiment, an interface circuit includes an amplifier configured to be coupled to a transducer, a first bypass circuit coupled to a first voltage reference and the amplifier, a second bypass circuit coupled to the first voltage reference and the amplifier, and a control circuit coupled to the second bypass circuit. The first bypass circuit conducts a current when an input signal amplitude greater than a first threshold is applied to the transducer and the control circuit causes the second bypass circuit to conduct a current for a first time period after the first bypass circuit conducts a current.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawing, in which:

FIG. **1** illustrates a block diagram of an embodiment microphone system;

FIG. **2** illustrates a schematic of an embodiment MEMS microphone system;

FIG. **3** illustrates a waveform diagram of an embodiment microphone system in operation;

FIG. **4** illustrates a schematic of an embodiment current detection block;

FIG. **5** illustrates a schematic of another embodiment current detection block;

FIG. **6** illustrates a schematic of another embodiment MEMS microphone system; and

FIG. **7** illustrates a block diagram of an embodiment method of operation of a microphone system.

Corresponding numerals and symbols in the different figures generally refer to corresponding parts unless otherwise indicated. The figures are drawn to clearly illustrate the relevant aspects of the embodiments and are not necessarily drawn to scale.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The making and using of various embodiments are discussed in detail below. It should be appreciated, however, that the various embodiments described herein are applicable in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative of specific ways to make and use various embodiments, and should not be construed in a limited scope.

Description is made with respect to various embodiments in a specific context, namely microphone transducers, and more particularly, MEMS microphones. Some of the various embodiments described herein include MEMS transducer systems, MEMS microphone systems, interface circuits for transducer and MEMS transducer systems, biasing circuits for MEMS transducer systems, and shock protection and recovery for MEMS transducer systems. In other embodiments, aspects may also be applied to other applications involving any type of sensor or transducer converting a physical signal to another domain and interfacing with electronics according to any fashion as known in the art.

An aspect of the embodiments described herein provides an interface circuit for a microphone that biases the microphone, protects the microphone during a shock event, and rapidly restores a voltage bias after a shock event. According to various embodiments, a current is induced in various parts of the interface circuit during a shock event, the current is detected by a current detection block, and a control circuit receives information related to the detected current and modifies an impedance of a portion of the interface circuit. In some embodiments, the impedance is modified for a time period during and/or after the shock event. With respect to specific embodiments, the impedance is lowered during and/or after the shock event, thereby allowing the voltage bias to be more quickly restored.

FIG. **1** illustrates a block diagram of an embodiment microphone system **100** including a bias and shock circuit **104** coupled to microphone **102** and amplifier **106**. In the block diagram illustrated, microphone system **100** receives a sound wave **108** as an input into microphone **102**. In various embodiments, microphone **102** may include a capacitive MEMS microphone with a backplate and diaphragm. The sound wave **108** may cause the diaphragm to be displaced, producing a voltage signal output from microphone **102** into bias and shock circuit **104**, which then supplies the voltage signal to amplifier **106**. According to various embodiments, bias and shock circuit **104** maintains a bias charge level on microphone **102** during normal operation. In specific embodiments, the bias charge level on microphone **102** is directly related to the sensitivity of microphone system **100**.

Amplifier **106** may have a gain A. In other embodiments, amplifier **106** may be part of a multi-stage amplifier circuit resulting in an overall gain of A. During normal operation, sound wave **108** is converted from a pressure signal to an amplified voltage signal by microphone system **100**.

According to various embodiments, bias and shock circuit **104** provides a current path for the charge on microphone **102** during a shock event and helps to restore a bias voltage on microphone **102** after the shock event. In various embodiments, a shock event may include dropping microphone system **100**, physical impact on a sound port of microphone system **100**, or extremely large sound signals in the environment, for example. In such a shock event, microphone **102** may be susceptible to damage if the bias charge on microphone **102** is not allowed to flow as current off microphone **102**. Bias and shock circuit **104** may provide current paths from microphone **102** to a reference voltage, such as a voltage source or ground terminal for example.

Following a shock event, bias and shock circuit **104** may modify an impedance value of a coupling between microphone **102** and a reference voltage in order to more quickly restore the bias voltage value. In various embodiments, because the bias voltage (i.e. the amount of charge on the microphone) is affected during a shock event, the sensitivity following a shock event will be substantially affected. If the sensitivity is not restored quickly, altered microphone system performance may be detectable by a human observer. For example, the quality of a recorded signal will be audibly affected. In a specific embodiment, bias and shock circuit **104** may close a switch between a reference voltage and microphone **102** for a period of time. In some embodiments, the period of time may begin during the shock event. In other embodiments, the period of time may begin after the shock event. The period of time when the switch is closed may be set to a specific time period. In some embodiments, a current flowing through the closed switch may be monitored and the switch may be opened when the current approaches a threshold value.

FIG. **2** illustrates a schematic of an embodiment MEMS microphone system **200** including a capacitive MEMS microphone **210** attached to an interface circuit **220** via terminals **206** and **208**. MEMS microphone **210** includes a deflectable membrane **204** coupled to terminal **208** and a perforated rigid backplate **202** coupled to terminal **206**. According to various embodiments, a sound wave from a sound port (not shown) incident on membrane **204** causes membrane **204** to deflect. The deflection changes the distance between membrane **204** and backplate **202**, thereby changing the capacitance because backplate **202** and membrane **204** form a parallel plate capacitor. The change in capacitance is detected as a voltage change between terminals **206** and **208**. Interface circuit **220** measures the voltage change between terminals **206** and **208** and provides an output signal at output **234** that corresponds to the sound wave incident on membrane **204**.

In the embodiment shown, amplifier **212** is coupled to terminal **206** and receives voltage signals from MEMS microphone **210**. Amplifier **212** amplifies the voltage signals received from MEMS microphone **210** and provides the output signal to output **234**. In other embodiments, amplifier **212** is the first stage in a multi-stage amplifier cascade. As specifically shown, amplifier **212** may be a source-follower amplifier.

According to various embodiments, MEMS microphone system **200** has a sensitivity that is directly related to a bias voltage applied via terminals **206** and **208** to backplate and diaphragm **202** and **204**, respectively. Because the sensitivity is directly related to bias voltage, MEMS microphone system **200** may be operated with a constant amount of charge on backplate **202** and diaphragm **204**. Charge pump **218** and voltage source **232** may together supply the bias voltage to MEMS microphone **210** and establish the constant amount of charge. In various embodiments, a small leakage current may be present between backplate **202** and diaphragm **204**. Charge pump **218** and voltage source **232** may also compensate for the small leakage current.

In order to maintain a constant charge on backplate **202** and diaphragm **204**, an impedance seen from terminal **206** may be very large. In some specific embodiments, the impedance may be on the order of 10 GΩ In other specific embodiments, the impedance may be on the order of 100 GΩ or higher.

If a shock event occurs, the charge on the MEMS microphone **210** may forward bias diode **222** (for a pressure increase shock) and/or diode **228** (for a pressure decrease shock) coupled to terminal **206** at an input to amplifier **212** and cause a current to flow through diode **222** and/or diode **228**. Because terminal **206** is a high impedance input to interface circuit **220**, a voltage change may be applied before either diode **222** or **228** is forward biased and conducts a current. In some embodiments, an anti-parallel diode **224** may be included next to diode **222** and coupled terminal **206** in order to bias the circuit node at terminal **206**. Diode **224** operates only if the voltage difference between voltage source **232** and terminal **206** is above the diode drop of **224**. In some embodiments, diode **224** improves biasing during startup. In additional embodiments, diode **224** provides biasing current in case of MEMS leakage while maintaining a high input impedance at terminal **206**.

In the embodiment shown, current detect block **214** is coupled between diode **222** and voltage source **232** and current detect block **215** is coupled between diode **228** and a ground node. Current detect block **214** detects a current through diode **222** and current detect block **215** detects a current through diode **228**. In alternative embodiments, a single current detect block **214** may be used. In further embodiments, current detect block **214** may be coupled to other circuit elements in other positions within interface circuit **220**.

After a shock event, because charge has moved off the MEMS microphone **210**, the sensitivity may be altered. In some embodiments, because diodes **222** and **228** only conduct a current during a shock event, a current detected in either current detect block **214** or **215** is indicative of a shock event. According to various embodiments, current detect block **214** or **215** is used to indicate a shock event via a detected current by providing a current detect signal to logical OR gate **216**. In other embodiments, OR gate **216** may be implemented using other digital logic or control circuits and may include control logic other than a logical OR. OR gate **216** provides switch control signal **230** to switch **226**. Switch **226** is coupled in parallel with diode **222** and, when closed, bypasses diode **222** and lowers the impedance seen at terminal **206**. According to various embodiments, a detected current by current detect block **214** or **215** may cause OR gate **216** to close switch **226** using switch control signal **230**. Closing switch **226** may more rapidly restore the constant charge amount on MEMS microphone **210** from voltage source **232** and restore the nominal sensitivity after a shock event.

According to various embodiments, restoring nominal sensitivity and function of a microphone after a shock event is completed in less than 50 ms. In some embodiments, due to the high impedance of the circuit attached to terminal **206**, restoring a constant charge amount on MEMS microphone **210** may take between 50 ms and 1-10 seconds if switch **226** is open. However, if switch **226** is closed, restoring a constant charge amount on MEMS microphone **210** may take less than 50 ms. In some embodiments, restoring a constant charge amount on MEMS microphone **210** may take less than 10 ms if switch **226** is closed. In further embodiments, restoring a constant charge amount on MEMS microphone **210** may take less than 50 μs if switch **226** is closed. In accordance with such various embodiments, a time period after a shock event during which switch **226** remains closed may have variable length. The time period may be a fixed time, such as 20 ms for example. In some embodiments, the time period may depend on a current detected signal from current detect block **214** or **215**.

According to another embodiment, when MEMS microphone system **200** is turned on, establishing an initial charge level on MEMS microphone **210** may be delayed because of the high impedance seen at terminal **206**. In such an embodiment, input **236** may be used to indicate a start-up condition to OR gate **216**, which will provide switch control signal **230** to close switch **226**. Closing switch **226** during a start-up condition may enable MEMS microphone system **200** to reach an operating charge level and nominal sensitivity more quickly, as described above with reference to shock recovery.

FIG. **3** illustrates a waveform diagram of an embodiment microphone system **300** in operation and demonstrates improved shock recovery when various aspects of embodiments described herein are employed. Waveform **302** depicts an output voltage of a microphone system having no functionality of shock detection and recovery and waveform **304** depicts a bias voltage applied to a microphone within the microphone system. Waveform **306** depicts a shock detection signal and waveform **308** depicts a shock stimulus. Waveform **310** depicts the output voltage of a microphone system with shock detection and recovery and waveform **312** depicts the bias voltage applied to a microphone with shock detection and recovery. According to various embodiments, the output voltage may correspond to output **234** in FIG. **2**, and the bias voltage may correspond to a voltage applied between terminals **206** and **208** in FIG. **2**, for example.

According to the embodiment shown, shock recovery is faster with detection and recovery functionality according to embodiments described herein. At time **314**, which is less than 100 ms after a third shock event, output voltage waveform **302** and bias voltage waveform **304** are substantially separated from the respective initial values. At time **314**, output voltage waveform **310** and bias voltage waveform **312**, having shock recovery, are much closer to the initial values compared to waveforms **302** and **304**, having no shock recovery.

FIG. **4** illustrates a schematic of an embodiment current detection block **400** that may be used to implement current detect block **215** in FIG. **2**. In the embodiment shown, a current flows through resistor **402** and diode **404**. In various embodiments, diode **404** corresponds to diode **228** in FIG. **2**. Resistor **402** converts the current, which may be produced by a shock event, to a voltage. In some embodiments, a shock event may cause diode **404** to be forward biased if an input voltage is more than one diode drop below ground. If diode **404** is forward biased, comparator input signal **410** may be pulled below ground and cause output **408** to go high. Input signal **410** is compared to a second input (GND) of the comparator at MOSFET **418**. The comparison result is then output on output **408**, which may drive OR gate **216** in FIG. **2**, for example. In another embodiment, the output **408** may include a hysteresis, which is not shown in the drawing. The same current detection block can be used to implement current detect block **214** for detecting the current through diode **222** in FIG. **2** by exchanging the NMOS/PMOS and VDD/GND connections, as is known by those skilled in the art.

FIG. **5** illustrates a schematic of another embodiment current detection block **500** that also may be used to implement current detect block **215** in FIG. **2**. In the embodiment shown, a MOSFET **502** is coupled to an input and is configured as a MOS diode. In various embodiments, this MOS diode corresponds to the diode **228** in FIG. **2**. MOSFET **502** is coupled to the remainder of current detection block **500** which compares the current flowing through MOSFET **502** with reference current source **506**. If a voltage on the input drops below ground by the diode drop of the MOS diode with MOSFET **502**, current flows through MOSFET **502** from ground to input. Such a current will cause MOSFET **504** to conduct a current because MOSFETs **502** and **504** are coupled as a current mirror. If the current flowing through MOSFET **504** is larger than reference current source **506**, output **508** indicates a detected current by going high. In some embodiments, output **508** is coupled to OR gate **216**. In some embodiments, current detection block **500** could be reoriented with respect to a voltage source (instead of ground) by exchanging NMOS/PMOS and VDD/GND in order to implement current detect block **214** in FIG. **2**, for example.

FIG. **6** illustrates a schematic of another embodiment MEMS microphone system **600** having current detect blocks **614** and **615** and diodes **622** and **628** attached to an output of amplifier **612**. Operation of MEMS microphone system **600** with MEMS microphone **610** and interface circuit **620** is similar to MEMS microphone system **200** with MEMS microphone **210** and interface circuit **220**. Placement of current detect blocks **614** and **615** and diodes **622** and **628** on an output of amplifier **612** provides a different measurement point, but operation of MEMS microphone system **600** is generally the same as described with reference to MEMS microphone system **200** in FIG. **2** and will not be described again.

FIG. **7** illustrates a block diagram of an embodiment method of operation **700** of a microphone system including steps **702**, **704**, and **706** for protecting against and recovering from a shock event to a microphone. Step **702** includes conducting a current caused by a shock event away from plates of the microphone. Step **704** includes detecting the current flowing away from the plates of the microphone. Step **702** may correspond to forward biasing a diode. In other embodiments, step **702** may correspond to closing a switch. Following step **704**, step **706** includes reducing the impedance of an interface circuit coupled to the plates of the MEMS microphone. In various embodiments, reducing the impedance of an interface circuit may include closing a switch. In further embodiments, the switch may be coupled between a plate of the MEMS microphone and a reference voltage source. In specific embodiments, step **706** may include reducing the impedance for a specific time period until the plates of the MEMS microphone have a nominal charge level with a corresponding sensitivity value.

In accordance with an embodiment, an interface circuit includes an amplifier configured to be coupled to a transducer, a first bypass circuit coupled to a first voltage reference and the amplifier, a second bypass circuit coupled to the first voltage reference and the amplifier, and a control circuit coupled to the second bypass circuit. The first bypass circuit conducts a current when an input signal amplitude greater than a first threshold is applied to the transducer and the control circuit causes the second bypass circuit to conduct a current for a first time period after the first bypass circuit conducts a current.

In various embodiments, the first bypass circuit includes a diode. The interface circuit may also include a first current detection block coupled to the first bypass circuit and the second bypass circuit. In some embodiments, the first current detection block provides a control signal indicative of a detected current to the control circuit. The second bypass circuit may include a semiconductor switch having a first conduction terminal coupled to the first voltage reference, a second conduction terminal coupled to the amplifier, and a control terminal for receiving a switching control signal. In accordance with an embodiment, the control circuit receives the control signal from the first current detection block and provides the switching control signal to the control terminal of the second bypass circuit.

According to some embodiments, the interface circuit includes a third bypass circuit coupled to a second voltage reference and the amplifier, and the third bypass circuit conducts a current when an input signal amplitude greater in magnitude than a second threshold is applied to the transducer. The interface circuit may also include a second current detection block coupled to the third bypass circuit, and the second current detection block provides an additional control signal indicative of a detected current to the control circuit.

In various embodiments, the first, second, and third bypass circuits are coupled to an input of the amplifier. The control circuit causes the second bypass circuit to conduct a current for the first time period dependent on the switching control signal. The control circuit includes digital control logic in some embodiments. The interface circuit may include a bias generator configured to be coupled to the transducer. In some embodiments, the interface circuit includes the transducer. The transducer may be a capacitive microelectromechanical system (MEMS) microphone having a backplate and a deflectable membrane.

In accordance with an embodiment, a method of operating a transducer includes conducting a current from the transducer when an input signal having an amplitude greater in magnitude than a threshold value is input to the transducer, detecting the current from the transducer, and reducing an impedance between the transducer and a voltage source after detecting the current. The method may also include maintaining a constant charge on the transducer during normal operation. In some embodiments, reducing the impedance between the transducer and a voltage source includes closing a switch coupled between the transducer and a voltage source. The method may further include reducing the impedance between the transducer and the voltage source during a startup phase.

In accordance with an embodiment, a microphone system includes a capacitive MEMS microphone, an amplifier coupled to a first capacitive plate of the MEMS microphone, and a charge control circuit coupled to the amplifier. The charge biasing circuit includes a first diode coupled to the amplifier, a bypass switch coupled to the amplifier and in parallel with the first diode, a current detection circuit coupled to the first diode and the bypass switch, and a switch control circuit coupled to the current detection circuit and controls the bypass switch.

In various embodiments, the microphone system includes a second diode coupled to the amplifier, an additional current detection circuit coupled to the second diode and to the switch control circuit, and/or a bias generator coupled to a second capacitive plate of the MEMS microphone. In some embodiments, the switch control circuit includes a logical OR gate. The first diode may be coupled to an input of the amplifier. The microphone system may include a third diode coupled in parallel with the first diode, and an anode of the first diode may be coupled to a cathode of the third diode.

Advantages of various aspects of the embodiments and modifications thereof as described herein include directly sensing a change of stored charge on a capacitive MEMS sensor through detecting a current after the high impedance node, start and end time detection for shock events without introducing disturbing observers to the system, shock detection with improved reliability, shock detection independent of biasing conditions, and shock detection without added parasitic components or noise sources. A further advantage includes quickly biasing a microphone to a nominal bias voltage following a shock event and during a start-up phase.

While this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to persons skilled in the art upon reference to the description. It is therefore intended that the appended claims encompass any such modifications or embodiments.

What is claimed is:

1. An interface circuit comprising:

an amplifier configured to be coupled to a transducer;

a first bypass circuit coupled to a first voltage reference and the amplifier, wherein the first bypass circuit is configured to conduct a first current when an input signal amplitude greater than a first threshold is applied to the transducer;

a second bypass circuit coupled to the first voltage reference and the amplifier; and

a control circuit coupled to the second bypass circuit and configured to cause the second bypass circuit to conduct a second current for a first time period after the first bypass circuit conducts the first current.

2. The interface circuit of claim **1**, wherein the first bypass circuit comprises a diode.

3. The interface circuit of claim **1**, further comprising a first current detection block coupled to the first bypass circuit and the second bypass circuit, wherein the first current detection block is configured to

detect the first current, and

provide a control signal indicative of detecting the first current to the control circuit.

4. The interface circuit of claim **3**, wherein the second bypass circuit comprises a semiconductor switch having a first conduction terminal coupled to the first voltage reference, a second conduction terminal coupled to the amplifier, and a control terminal configured to receive a switching control signal.

5. The interface circuit of claim **4**, wherein the control circuit is further configured to receive the control signal from the first current detection block and provide the switching control signal to the control terminal of the second bypass circuit.

6. The interface circuit of claim **5**, further comprising:

a third bypass circuit coupled to a second voltage reference and the amplifier, wherein the third bypass circuit is configured to conduct a current when an input signal amplitude greater in magnitude than a second threshold is applied to the transducer; and

a second current detection block coupled to the third bypass circuit, wherein the second current detection block is configured to provide an additional control signal indicative of a detected current to the control circuit.

7. The interface circuit of claim **6**, wherein the first, second, and third bypass circuits are coupled to an input of the amplifier.

8. The interface circuit of claim **5**, wherein the control circuit is further configured to cause the second bypass circuit to conduct a current for the first time period dependent on the switching control signal.

9. The interface circuit of claim **5**, wherein the control circuit comprises digital control logic.

10. The interface circuit of claim **1**, further comprising a bias generator configured to be coupled to the transducer.

11. The interface circuit of claim **1**, further comprising the transducer.

12. The interface circuit of claim **11**, wherein the transducer is a capacitive microelectromechanical system (MEMS) microphone having a backplate and a deflectable membrane.

13. A method of operating a transducer comprising:

conducting a current from the transducer when an input signal having an amplitude greater in magnitude than a threshold value is input to the transducer;

detecting the current from the transducer; and

reducing an impedance between the transducer and a voltage source after detecting the current.

14. The method of claim **13**, further comprising maintaining a constant charge on the transducer during normal operation.

15. The method of claim **13**, wherein

conducting the current from the transducer comprises conducting the current through a bypass circuit,

detecting the current from the transducer comprises detecting the current at a current detection circuit coupled to the bypass circuit, and

reducing the impedance between the transducer and the voltage source comprises closing a switch coupled between the transducer and a voltage source based on detecting the current at the current detection circuit.

16. The method of claim **13**, further comprising reducing the impedance between the transducer and the voltage source during a startup phase.

17. A microphone system comprising:

a capacitive microelectromechanical system (MEMS) microphone;

an amplifier coupled to a first capacitive plate of the MEMS microphone; and

a charge control circuit coupled to the amplifier, wherein the charge control circuit comprises:

a first diode coupled to the amplifier;

a bypass switch coupled to the amplifier and in parallel with the first diode;

a current detection circuit coupled to the first diode and the bypass switch and configured to detect a current in the first diode; and

a switch control circuit coupled to the current detection circuit and configured to control the bypass switch based on information received from the current detection circuit.

18. A microphone system comprising:

a capacitive microelectromechanical system (MEMS) microphone;

an amplifier coupled to a first capacitive plate of the MEMS microphone; and

a charge control circuit coupled to the amplifier, wherein the charge control circuit comprises:

a first diode coupled to the amplifier;

a bypass switch coupled to the amplifier and in parallel with the first diode;

a current detection circuit coupled to the first diode and the bypass switch; and

a switch control circuit coupled to the current detection circuit and configured to control the bypass switch;

a second diode coupled to the amplifier; and

an additional current detection circuit coupled to the second diode and to the switch control circuit.

19. The microphone system of claim **17**, further comprising a bias generator coupled to a second capacitive plate of the MEMS microphone.

20. The microphone system of claim **17**, wherein the switch control circuit comprises a logical OR gate.

21. The microphone system of claim **17**, wherein the first diode is coupled to an input of the amplifier.

22. A microphone system comprising:

a capacitive microelectromechanical system (MEMS) microphone; an amplifier coupled to a first capacitive plate of the MEMS microphone; and a charge control circuit coupled to the amplifier, wherein the charge control circuit comprises:

a first diode coupled to the amplifier;

a bypass switch coupled to the amplifier and in parallel with the first diode; a current detection circuit coupled to the first diode and the bypass switch; and a switch control circuit coupled to the current detection circuit and configured to

control the bypass switch; and

a second diode coupled in parallel with the first diode, wherein an anode of the first diode is coupled to a cathode of the second diode.

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